Oilheat Industry Roadmap

— Toward a Sustainable Energy Future

March 2002

DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA ·

NORA
NATIONAL OILHEAT RESEARCH ALLIANCE

BROOKHAVEN
NATIONAL LABORATORY

The U.S. Department of Energy supports oil heat research, development, deployment, education, and training. DOE provides support to Brookhaven National Laboratory, the National Oilheat Research Alliance, and the Petroleum Marketers Association of America for research on combustion equipment, fuel quality improvements, and education and outreach on oilheat uses in residential, commercial, and institutional buildings. DOE is pleased to support the oilheat industry in developing this Roadmap for collaborative research, development, and deployment of advanced oilheat technologies, systems, and outreach to enhance the industry now and in the future. DOE thanks all who have participated in this roadmap process.

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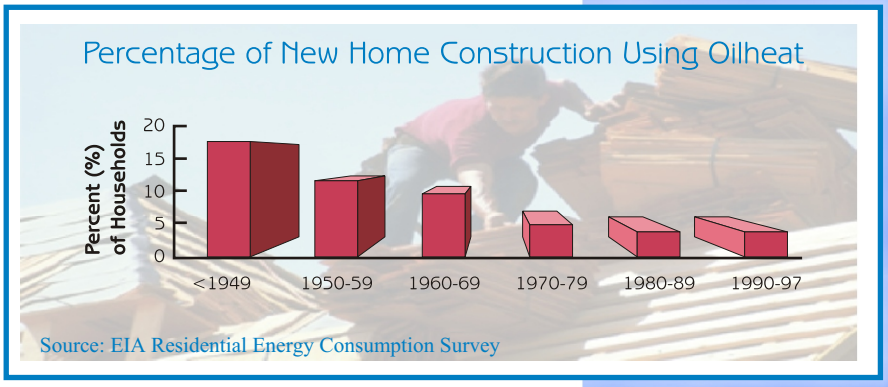
Executive Summary

The oilheat industry is forming strategic partnerships with the U.S. Department of Energy (DOE) and Brookhaven National Laboratory (BNL) to make technological advancements that will reduce the cost and increase the efficiency of oilheat, both today and into the future. The oilheat industry is motivated to take a major step forward in regaining market share and making oilheat *a fuel of choice*. The Petroleum Marketers Association of America (PMAA) and the newly formed National Oilheat Research Alliance (NORA) are facilitating working relationships throughout the oilheat industry and with government to make these goals a reality. High electricity prices, uncertain energy supplies, volatile natural gas spikes, and uneven electricity deregulation policies in the U.S., are opening the door for oilheat. It is time to cross the threshold into the 21st century.

The oilheat industry is in a compromised position. It markets a commodity over which it has limited control - of the source, quality, price, and availability. Yet, the industry has managed to be a clean, cost-efficient supplier of premium indoor comfort to over 10 million homes in the United States. Leaders of the oilheat industry have taken a further step forward in developing a vision and roadmap for research, development, and commercialization of new products and systems. The result of this effort is this document, the *Oilheat Industry Roadmap- Toward a Sustainable Energy Future*. The *Roadmap* provides a framework for recognizing both future challenges to the oilheat industry and opportunities for strategic public and private partnerships that will address these challenges through a set of specific actions, ultimately achieving the vision for the future.



The Oilheat Industry Roadmap process began with a Vision Workshop held at Brookhaven National Laboratory in August 2001. Oilheat dealers, researchers, equipment manufacturers, and other stakeholders considered the most critical market, regulatory, institutional, and technology issues affecting the future of oilheat and created a vision for 2020 and beyond. The vision is shown below:

> The oilheat industry will be a customer-driven supplier of premium indoor comfort. Oilheat will be a consumer fuel of choice - affordable, environmentally friendly, and offering total energy solutions for on-site space heating and cooling, hot water, and power. By capitalizing on its already strong infrastructure, the industry will provide worry-free, self-sufficient, virtually invisible energy systems to its customers. The oilheat industry will regain its commercial and

institutional customers and expand its residential market. New niche markets will be developed, to capture a substantial portion of not only the heating market, but also the total energy market by the year 2020.

The culminating event of this process was the Oilheat Industry Roadmap Workshop, held at College Park, Maryland, in November 2001. This meeting brought together participants from the Vision workshop, as well as other equipment manufacturers, oilheat dealers, researchers, and marketers to discuss a strategy to achieve the industry's vision of the future. As a result, the *Oilheat Industry Roadmap: Toward a Sustainable Energy Future* consists of a series of specific actions in three areas: **improving fuel quality and performance, enhancing equipment and service, and expanding markets and applications**, all designed to realize the Vision.

Improve Fuel Quality and Performance. Improvements in fuel quality and performance have the potential to enhance oilheat's competitive edge in the marketplace. The following actions will result in an increase of system efficiency and reduction of NOx, SO_2, and particulate matter emissions:

- **Research applications of liquid biofuels.** Biofuels offers a low sulfur substitute for heating oil. In transportation applications, a combination of 20% biodiesel and 80% diesel fuel provides 98-99% as much power, torque, and fuel efficiency.

- **Develop additive performance data**. Additives improve fuel performance characteristics and prevent accumulation of contaminates within fuel tanks. A database of additive performance information will give dealers the information they need to improve fuel quality.

- **Develop an educational program on the benefits of premium low sulfur oil**. Low sulfur fuel maintains system efficiency, leading to extended service-free intervals and cost savings. A New York State Energy Research and Development Authority (NYSERDA) study has estimated that New York homeowners could lower their fuel costs by $11 million a year through improved energy efficiency from low-sulfur fuel oil.

Enhance Oilheat Equipment and Service. Enhancements in oilheat equipment and service will reduce malfunctions, lower total installed systems costs, maintain high efficiencies, and lower environmental emissions. Research and development programs in the following areas will ultimately lead to an expansion of markets and applications:

- **Lower the total installed cost of the oilheat system**. Lowering the total installed cost of highly efficient systems is critical for oilheat to penetrate more of the heating market.

- **Develop self-diagnostic and self-adjusting control technologies**. By incorporating sensors and controls, the oilheat system has the potential to be virtually invisible. Self-adjusting technologies compensate for and correct problems, limiting unplanned service calls to once every two to three years.

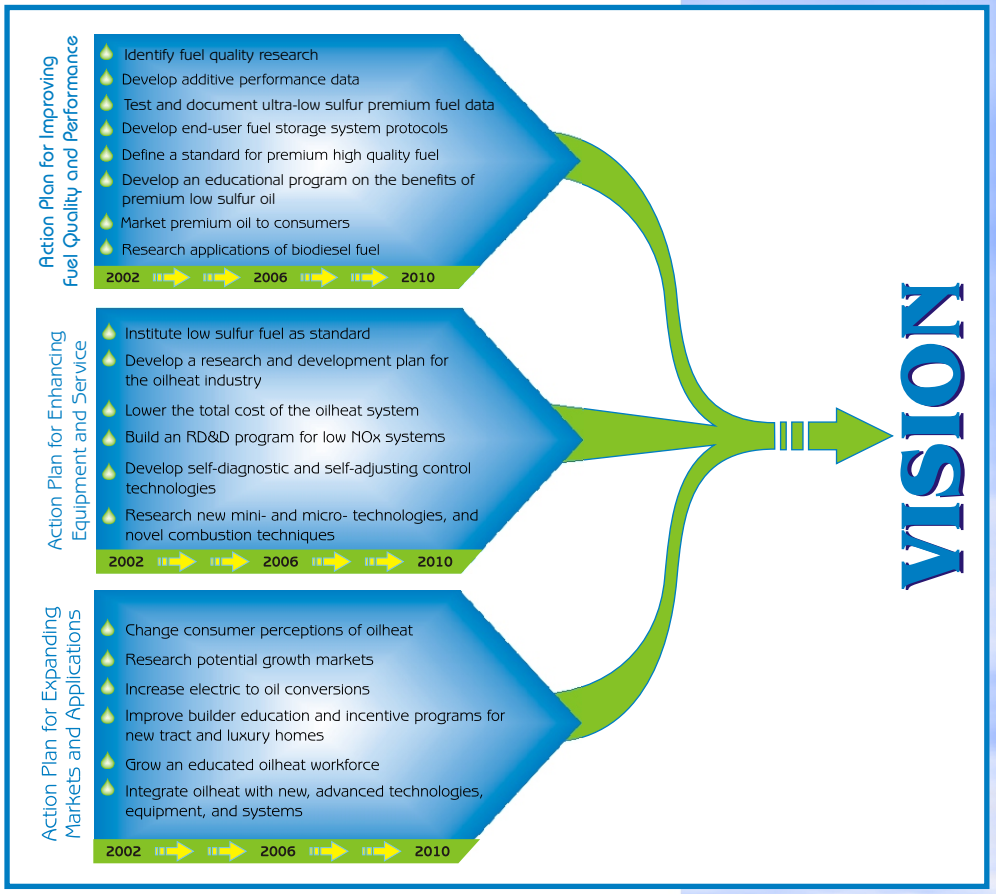
- **Research novel combustion techniques**. Modulating burners and low-fire concepts, among other new technologies, could revolutionize the industry, making oilheat a near zero-emission, highly efficient, low cost fuel.

Expand Markets and Applications. Expansion of markets and applications is the pinnacle of the roadmap. Through these and other actions, oilheat's future in the energy marketplace for the 21st century and beyond will be secured:

- **Change consumer perceptions about oilheat**. Consumers should know oilheat is a clean, energy efficient, cost-effective, versatile fuel. Advertisements through television, radio, and newspaper will convey the benefits of oilheat to the consumer.

- **Increase electric to oil conversions**. Electric resistance heat is as efficient as the power plant supplying electricity to the grid, on average 33%. Oilheat systems are located on-site and are typically over 80% efficient. This offers cost and environmental benefits for consumers.

- **Integrate oilheat with new, advanced, building technologies, equipment, and systems**. Oil-fired energy systems may be used to fuel on-site electricity generation including photovotaics and fuel cells, domestic hot water, air conditioning, desiccant cooling and humidity control systems.

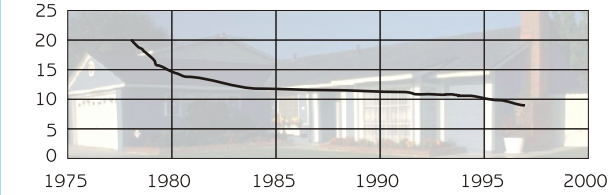


Introduction

Oilheat: A Fuel of Choice

More than 10 million households in the United States are heated with oil. It is a safe, economical, clean burning, and energy-efficient fuel. For over 50 years, oil has been the primary space heating fuel for homes, businesses, and schools in both Northeastern and Central Atlantic states.

Oilheat surfaced as a primary heating fuel in the 1940's and 1950's, replacing coal furnaces, which required daily attention and maintenance. At that time, oil was seen as a modern, clean alternative to coal, which was much more difficult to store, often generated noxious fumes, and resulted in ashes and cinder which homeowners had to dispose of manually. The combination of the Gulf oil crisis of the 1970's, aggressive marketing by the natural gas industry, and the public's misconception of oilheat as old-fashioned and environmentally harmful, have all led to a gradual decline in the percentage of U.S. households using oilheat.



Source: EIA Residential Energy Consumption Survey

Oilheat offers consumers a product that compares favorably with other home heating options. Modern oil burners produce negligible amounts of smoke and soot. Oil burning appliances are typically 85% efficient or higher. Homeowners and building managers receive the most value when they choose oil as a heating fuel.

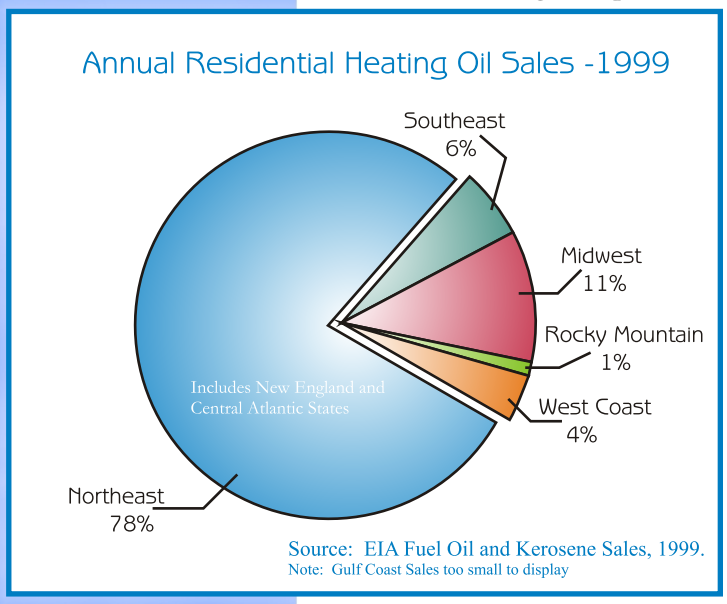
Not only is oil economical and efficient, it is also a very safe heating fuel. If an oilheat tank leaks, it is non-explosive. In addition, the risk of carbon monoxide exposure from the fuel is low. When a burner goes out of adjustment, oil generally generates smoke before high levels of carbon monoxide is released, alerting a homeowner or building manager of a potential problem. By contrast, it is impossible for building owners or managers to detect a carbon monoxide leak by simply looking at a natural gas or propane burner.

Oilheat's Use in the Marketplace

Residential heating oil is a middle distillate fuel; other middle distillates include kerosene, jet fuel, and highway diesel fuel. Refiners primarily produce heating oil in the winter, when demand is the highest. They can increase production to a modest degree; production levels then reach a point at which refiners may need to produce other petroleum products, which cannot be sold in sufficient quantities during those winter months. Thus, to help meet high winter demands, refiners build inventories in the prior summer and fall. However, if demand is high for another seasonal petroleum product, such as gasoline, refiners may delay production of heating oil, thus lowering inventories.

Refiners and importers ship heating oil by barge, tanker, rail, or pipeline into a central distribution area, such as New York Harbor, where it is then redistributed to wholesale terminal operations throughout the country. The product is then distributed by truck to local oilheat dealers for storage or sent directly to residential, commercial, and institutional consumers.

In addition to heating oil being a highly seasonal fuel, used primarily in the October to March time period, oilheated homes and buildings are primarily found in the Northeast, which includes New England and the Central Atlantic states. Of U.S. households that use oilheat, 69% are in the Northeast and account for 78% of 1999 residential heating oil sales.



The oilheat industry's unique and significant advantage over electric and natural gas is that it has access to a worldwide refining infrastructure and is easily and economically transported. For example, in the northeast transportation costs comprise 20% of oil's total cost, versus 80% for natural gas. In addition, heating oil is inexpensive to store in large wholesale terminals, helping to offset peak winter demand.

Across the country, oilheat is rarely installed in new home construction or in remodeled or renovated buildings. Eighteen percent of all new homes constructed before 1950 used oil as their main heating fuel; today that number has dropped to 4%. This is due to the fact that builders have little interest in the heating system operating costs but are very sensitive to capital costs required to heat homes. In turn, utilities offer builders cash subsidies to install natural gas or electric heating systems, and these subsidies are almost always paid by the rate payer, not the stockholders. Unfortunately, this is a state-by-state issue regulated by state public service commissions. The oilheat industry has been unsuccessful in eliminating this subsidy.

The Oilheat Industry Today

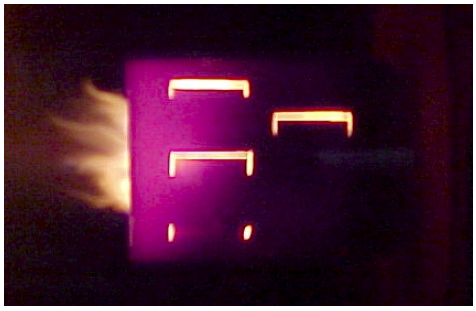
The U.S. oilheat industry employs more than 160,000 workers, most of whom are trained and highly skilled technicians in over 6,000 small, highly competitive, family-owned businesses. These small oilheat marketers, distributors, and suppliers compete for customers against local gas and electric utilities, as well as each other. Due to this highly competitive market, oilheat suppliers provide a full range of professional, in-home services exclusive to oil heat companies - an important advantage for homeowners and building managers. Oilheat industry professionals take great pride in providing superior servicing of oilheat equipment. Whether it is the middle of the night or in below-freezing temperatures,

servicemen are always available to diagnose and fix problems. Building on this customer service philosophy, the oilheat industry is striving to maintain and build their market share, as well as move into new niche markets.

The U.S. Department of Energy (DOE), in cooperation with oilheat marketers and equipment manufacturers, has, in past years supported improvements in the efficiency and technology of oil heating equipment. This cooperative relationship has led to tremendous advancements in the efficiency of oilheat equipment, saving consumers over $6 billion and resulting in savings of $500 for each $1 invested in research and development.

In 2000, Congress recognized the need for increased research, development and demonstration (RD&D), by passing the *National Oilheat Research Alliance (NORA) Act of 2000*, which created a national check-off program for the oilheat industry. Such check-off programs are voluntary, initiated and run by the industries that fund them. Implementing regulations are self-imposed and administered by members of the industry. Among the anticipated programs to be initiated with the oilheat funds, is collaborative research on oilheat technology enhancements, such as production of "clean oil" through the removal of sulfur and reduction of nitrogen, and improved transportation and storage. NORA and the Petroleum Marketers Association of America (PMAA) are facilitating a working relationship with leaders of the oilheat industry to enhance education and communication activities, and improve the public's perception of oilheat.

High-Flow Fan Atomization Burner



Forces Driving the Industry

Many factors will determine the future of oilheat in the U.S. over the next twenty years — technological change, market forces, customer needs, environmental pressures, and regulatory and institutional issues.

Technological Change

New energy technologies are playing an important role in determining the future of the oilheat industry. Low NOx burners (<50 ppm) allow oilheat to be as clean a heating option as any available and provide high equipment reliability. Two-stage burners improve efficiency, reduce cycling rates, and prolong the life of the oilheat system. Clean oil combustion technologies, such as the Fan Atomized Burner, are being developed to meet future environmental regulations and allow for integration of oilheat into total energy systems - heating, cooling, and power.

Information technologies are critical to all aspects of business. Smart technologies allow oilheat suppliers to manage their customers' heating systems more effectively. Many hours are already spent by technicians in diagnosing problems, but self-diagnostic equipment could be used to identify problems and cut back on service times. Flame quality monitors are being developed to notify customers when burners have to be serviced, instead of

waiting for the system to fail.

In the future, **technologies that supply heat as a byproduct of power** will help oilheat penetrate the buildings, cooling, heating, and power (BCHP) market. Oilheat thus will grow not only within the CHP market, but will help reach the CHP Challenge goal of 96 GW by the year 2010.

Improved tank technology will allow systems to be more environmentally friendly. Customers will not be concerned about tank leaks and environmental and economic impacts associated with them. Tanks will reduce fuel contamination, be appropriately sized, visually pleasing to the homeowner or building manager, and will maintain efficient fuel delivery.

Poor fuel performance accounts for up to one-half of service calls. Additives can improve fuel performance characteristics and prevent accumulation of contaminates within fuel tanks. Additive research can improve choices and effectiveness.

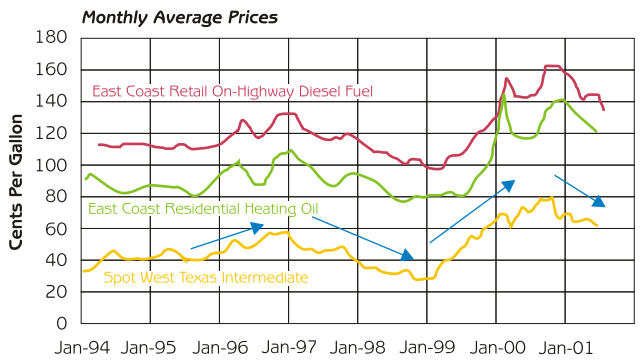
Biodiesel blended with distillate oil can provide a complete or partial substitute for oilheat when supplies are low. Biodiesel is manufactured from vegetable oils, cooking grease, or animal fats and can be used in combination with distillate oil or as a pure renewable fuel. Many states offer tax credits for the use of renewable fuels. Currently biodiesel is not exempt from federal and state taxes, but in the future biodiesel may be recognized as a "renewable fuel" and become eligible for tax incentives. The low sulfur content of biodiesel fuel will certainly meet future environmental regulations.

Market Forces

The price of crude oil on the world market drives the price of heating oil. The cost of heating oil, compared to competitive fuels (e.g., natural gas, propane, electricity) , drives its use in the marketplace. In areas of the U.S. where electricity and natural gas are transported short distances from the source of supply, they are preferred heating fuels. Electric baseboard systems usually have lower installed capital costs than oilheat systems, even though they are less energy efficient.

Although the residential sector is the primary market for oilheat, **the commercial sector**, which accounts for 36% of U.S. total energy consumption, presents a huge opportunity for oilheat. Forty-six percent (46%) of the U.S.'s electricity is consumed in the commercial energy space and water heating market. Currently, only 4% of commercial buildings nationwide use fuel oil for space and water heating, presenting a large market opportunity for this fuel.

Distillate Prices Increase with Crude Oil



Source: Spot Prices, S&P DRI Platt's; Retail, EIA

Environmental Pressures

Air quality emission regulations for sulfur and NOx are becoming increasingly stringent. In past years, the oilheat industry has been able to respond to environmental requirements for limiting sulfur and NOx. With new, cleaner oil burning technologies, oilheat should be able to respond again.

Underground tank leaks can become very costly to homeowners and building managers. Fortunately, many states have pollution funds, which cover all, or part of pollution from tank leaks; private insurance is also available for around $100 per tank.

Regulatory and Institutional Constraints

Oilheat's image stands in the way of improvements in market share. This image, an often negative one, results from lack of education. Consumers switch from oilheat to natural gas, for no other reason than their perception that natural gas is less expensive and cleaner; in reality, converting to gas or electricity does not make economic or environmental sense. From an environmental perspective, it is better to conserve a BTU of oil by replacing old equipment or improving energy efficiency, than to replace the system with a BTU of gas.

Consumers need to be educated about oilheat's cost effectiveness and environmental friendliness. Residential and commercial/institutional builders need better information and technical assistance on oilheat system design and installation. **A comprehensive marketing and education program** will help shed oilheat's negative image and improve the environment for attracting industry workers.

Federal and state transportation regulations specify the number of hours oilheat drivers may spend on the road. This has had a negative impact on the industry. Just recently, however, the U.S. Department of Transportation approved the *Oilheat Delivery of Hours of Service Program*. This program grants commercial motor vehicle drivers an exemption from hours-of-service restrictions when making winter home heating oil deliveries within a 100 air-mile radius of a central terminal or distribution point.

Fuel quality specifications will play a role in oilheat's future. Low sulfur fuel oil is beginning to gain favor as a home heating fuel. Current residential heating oil has an average sulfur value of 0.25%. Studies have shown that sulfur emissions lead to fouling of heating oil equipment, lowering system efficiency and increasing the need for frequent equipment cleaning. Low sulfur (0.05%) fuel oil is currently used in highway transportation; it can lower service costs and maintain oilheat system efficiency.

The heating industry is seasonal. Oilheat distributers respond to market demand by lowering their prices, affecting profitability. By contrast, the price of natural gas and electricity is allowed by state regulatory policies, to remain high during similar periods of low demand. This situation creates and unfair advantage for natural gas and electric utilities.

This Oilheat Roadmap articulates the oilheat industry's goals for the future, so as to secure a place for oilheat in the energy marketplace of the 21st century and beyond.

Background and Structure of the Oilheat Vision and Roadmap

In August of 2001, key representatives of the oilheat industry met with researchers and government officials at Brookhaven National Laboratory for the National Oilheat Industry Vision Workshop. This Workshop resulted in the publication of the National Oilheat Vision, which, in broad terms, outlines a vision for the oilheat industry and strategic goals that need to be addressed in achieving it.

Following the Vision Workshop, a National Oilheat Industry Roadmap Workshop was held on November 13-14, 2001, at the University of Maryland, College Park, Maryland. This meeting involved many of the same stakeholders as the Vision Workshop, and others as well, who creatively looked at solutions to technical, institutional, and market barriers facing the industry. Participants refined the vision and strategic goals, identified barriers that threaten the growth of the industry, and developed actions to overcome the barriers.

This roadmap, *The Oilheat Industry Roadmap—Toward a Sustainable Energy Future*, is a result of their deliberations. It consists of three main action areas:

- Improving fuel quality and performance
- Enhancing equipment and service
- Expanding markets and applications

The document also includes a list of participating organizations, oilheat resources, and key contact information.

Vision

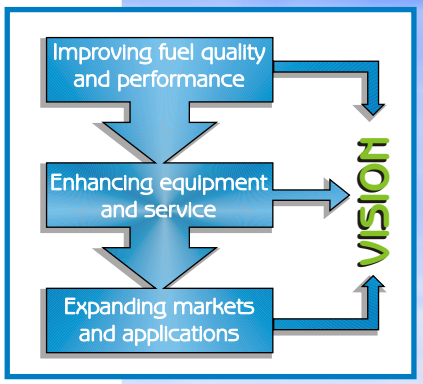
The Oilheat Industry will be a customer-driven supplier of premium indoor comfort. Oilheat will be a consumer fuel of choice - affordable, environmentally friendly, and offering total energy solutions for on-site space heating and cooling, hot water, and power. By capitalizing on its already strong infrastructure, the industry will provide worry-free, self-sufficient, virtually invisible energy systems to its customers. The oilheat industry will regain its commercial and institutional customers and expand its residential market. New niche markets will be developed, to capture a substantial portion of not only the heating market, but also the total energy market by the year 2020.

A 3,600 square foot home in Dutchess County, New York, previously had electric home heating and hot water costs totaling more then $8,500/year. After installing an oilheat system, annual heat-related costs are less than $1,800, with increased comfort.

Source: Energy Kinetics, Inc.

Reliable and Invisible

Oilheat will be one of the most reliable energy options of the future. Technological advancements in the fuel itself, as well as in burners, nozzles, and heat exchangers, will require little-to-no maintenance on the system. Self-diagnostic and monitoring equipment will alert homeowners and oilheat suppliers of potential problems that the dealer can correct before there is a system failure. Oilheat will be seen as an on-site distributed energy resource. It will provide heat and hot water even when there are electric power outages, and in future years, will be used to generate reliable electric power, a necessity for computer and electronic equipment.



The oilheat industry already has a strong infrastructure in place. There is no need to build additional pipelines or wires, just better storage tanks. In the future, these tanks will be integrated into buildings. The innovative tanks will be paired with reliable equipment that is self-monitoring and self-adjusting; thus, in addition to providing superior customer service, the oilheat system will be virtually invisible.

Versatile and Affordable

Oil is a versatile fuel in that it is portable and offers an array of indoor air comfort solutions. It can be easily transported to remote locations in a variety of ways. In the future, oilheat will provide total energy solutions, including space heating and cooling, domestic hot water, and

power generation. Oilheat will also fuel absorption chillers to provide cooling to residential and commercial buildings, and distributed generation systems, such as microturbines and fuel cells for on-site power generation.

During the past twenty years, oil prices have remained stable, except for short-term fluctuations. Homeowners will realize the cost savings of using oilheat as a premium solution to indoor air comfort.

Clean and Efficient

Oil will be a low emission fuel. Clean oil burners will cut current NOx emissions in half to 50-60 ppm, and, in combination with improved fuel quality, to 20 ppm. These emission reductions will help meet future environmental requirements and showcase oilheat as an environmentally responsible energy option.

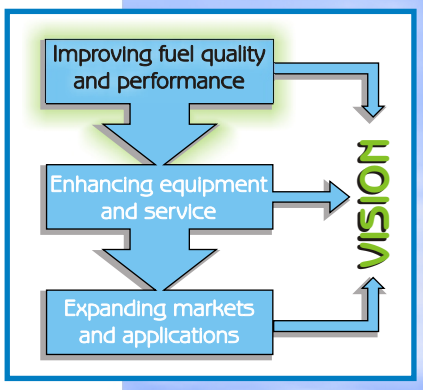
Oilheat is one of the most efficient heating alternatives and will continue to be so throughout the 21st century. Modern home heating oil equipment will achieve efficiency ratings greater than 85%. In addition to future advancements in burner technology, oilheat will prove to be a cost-effective on-site resource, eliminating unsightly wires, and high transmission and distribution losses, and instead, creating total system efficiencies close to 90%.

Improving Fuel Quality & Performance

The oilheat industry must strive to enhance oilheat fuel performance through improvements in fuel quality and storage systems. Problems associated with heating oil quality put the industry at a competitive disadvantage with other residential heating products, including natural gas and electric heat. Considering that fuel quality has decreased over the last 30 years, improving fuel quality must be a top priority for the industry.

The decline in fuel quality is attributed to refiners' preference for increasing the yield of a barrel of crude oil at the expense of fuel stability. Additionally, the quality and sulfur level of imported heating oil varies widely. The fuel's quality depends as well on the method by which it is stored, as most degradation occurs during storage. During storage, unstable fuels containing reactive fuel molecules combine to form larger macromolecules. In a process called "repolymerization," these macromolecules agglomerate into an undesired sludge. An additional problem affecting fuel quality is the presence of unwanted metallic elements.

A number of additives can be used to modify specific fuel properties and improve quality, enhance performance, and improve storage and handling characteristics. The most commonly used additives include flow improvers, detergents, antioxidants, corrosion inhibitors, metal deactivators, and biocides. Stabilizers are used to reduce "repolymerization" and detergents are used to reduce nozzle clogging, reduce soot build-up, and disperse sludge so that it can safely pass through the system. A metal deactivator can also be used to negate the degrading effects of copper particles. The additive's performance or fuel's response to a given additive must be measured to determine its dosage and effectiveness. Laboratory and field work analyzes how these various additive concentrations affect fuel quality and performance.

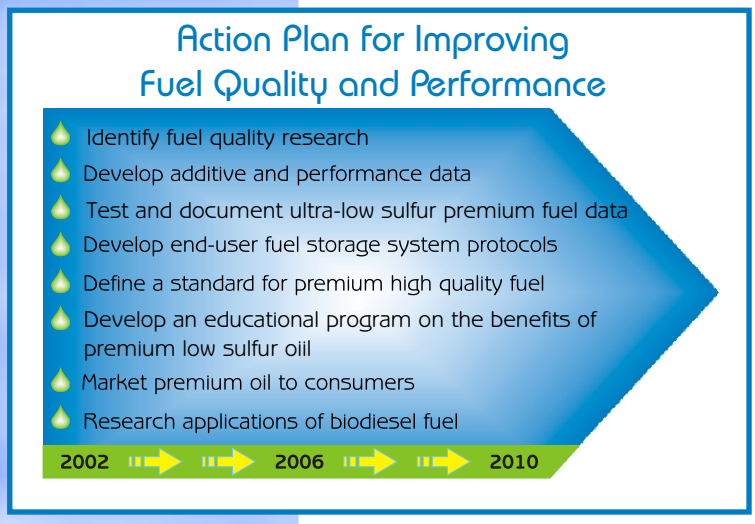


Improvements in fuel storage and quality have the potential to enhance oilheat's competitive edge in the marketplace. By utilizing existing research results and initiating new R&D, barriers may be successfully addressed and the vision of the oilheat industry will be achieved.

Barriers

Several technical, supply, market, regulatory, institutional, educational, and training barriers stand in the way of achieving the strategic goals the industry has set for itself and realizing its vision for 2020. Listed below are the most critical barriers facing oilheat fuel quality, performance, and storage:

- Inconsistency in fuel quality relative to fuel stability
- Lack of field data on fuel properties and additive performance
- Few financial incentives for refiners to develop clean oil products
- Low compliance with voluntary low-sulfur oil standards
- Lack of fuel quality standards and specifications
- Lack of funds for fuel quality research and development



Actions

The oilheat industry has identified eight priority actions that it believes will address the barriers to improving fuel quality, storage, and performance. With the exception of fuel system storage protocols and biodiesel fuel applications, successful completion of each action depends on the success of the others. All of them need to be addressed within five years and continued into the future. They are listed in chronological order; the first action needs to be completed before the second and so forth.

Identify Fuel Quality Research and Development

Currently, there is little or no collaboration among organizations on the progress of fuel quality research and development. Collaboration is needed, not to "reinvent the wheel," but to assist with the transfer of technical knowledge. Sweden and Germany, among other countries, have long been identified as countries in which research and development on fuel quality is highly advanced. Our nation's oilheat industry must strive to improve the flow of information among research organizations, both domestically and throughout the world. The first step in this process is to conduct a thorough literature search on fuel quality R&D, including both domestic and international sources. At the conclusion of the search, a technical **fuel quality research report** would be produced to identify and characterize completed or forthcoming fuel quality research. This project is currently being done by NORA.

Develop Additive Performance Data

Once the literature search is complete and additional data is compiled, a **database of additive performance information** can be created. Baseline data that proves the performance and effects of various fuel additives would be included in a technical document to serve as a repository of information and to provide a consistent method of tracking additive effectiveness. A product list and benefits analysis would be included in the technical document.

Test and Document Ultra-Low Sulfur Premium Fuel Data

The oilheat industry needs to develop **ultra-low sulfur premium fuel** data for the formulation of an ideal ultra-low sulfur premium oil. Refiners who currently produce ultra-low sulfur fuel oil would be asked to field test the product, so that performance data is obtained (50 ppm to 15 ppm). The data would be compiled into a technical document for widespread distribution.

Develop Fuel Storage System Protocols

Several **improvements in fuel storage systems** need to be made. A detailed assessment should be made on end user and wholesale storage capacity to assess how much storage capacity is available and in use. This assessment should additionally examine the quality of on-site storage. Tank technology needs to be improved as well, starting with research on the economics of plastic versus steel tanks. Oil tanks that are in smaller, compact shapes and sizes that fit more easily into residential, commercial and institutional buildings need to be developed and field tested. Using the information gained from this assessment, protocols for advanced tank technologies in residential and commercial buildings must be developed. The protocols address improved installation, repair, and maintenance of fuel storage systems. Research and development on fuel lines must also be conducted. A training program on installation and maintenance of newer, more advanced fuel storage systems would follow development of the protocols.

Define a Standard for Premium High Quality Fuel

Using all of the information gathered from the actions described above, regarding additive performance data and ultra-low sulfur premium fuel, a **standard for premium high quality fuel** must be developed. The final product of this action would be publication of a position paper designed to convince dealers to demand a premium high quality fuel and refiners to produce a uniform, high quality heating oil product. This document would be written for dealers and refiners, published in appropriate journals, and distributed at meetings and workshops. An international task force will be formed to develop an implementation strategy that will effectively ensure broad supplier compliance with the premium high quality standard.

Develop an Education Program On the Benefits of Premium Low-Sulfur Oil

Premium low-sulfur oil offers many benefits to heating oil retailers, as well as to consumers. Premium low-sulfur oil improves the quality of a dealer's job through enhanced cleanliness and extended service-free intervals; this ultimately leads to better customer retention by the industry. Premium oil results in lower service costs, which benefits dealers and retail consumers. One of the most significant benefits of premium, low-sulfur oil is that it has a more benign impact on the environment. A New York State Energy Research and Development (NYSERDA) study found that the use of low-sulfur fuel oil could provide an estimated environmental cost-benefit of $137 million a year. New York State homeowners can lower their fuel costs by approximately $11 million a year through improved energy efficiencies from low-sulfur fuel oil. In addition, annual service costs can be potentially reduced by $65 million a year by switching to low-sulfur oil.

The use of low-sulfur fuel oil could provide an estimated environmental cost-benefit of $137 million a year.

An **education program** on these benefits must be developed for oil dealers, as they must be persuaded to make the product available to consumers. Consumers of premium low-sulfur oil will ultimately need to be educated on the benefits as well. A technical document on low-sulfur oil should be produced and distributed to dealers. Written and web-based information materials, including fact sheets and flyers, in addition to articles in trade magazines and newsletters, are instrumental to the education program. Forums or conferences in which dealers participate, would provide important opportunities for facilitating open discussions on the benefits of low-sulfur oil.

Market Premium Oil to Consumers

A **marketing program for oil dealers** on the benefits of low-sulfur premium oil must be developed. The purpose of such a program would be to increase the sale of this premium product by marketing its physical aspects and benefits of the fuel to all consumers, in hopes of achieving 50% market penetration by 2005. Several media sources should be utilized for the program, including newspapers, magazines, and radio. Dealers should provide their customers with written information about the benefits of low-sulfur premium oil.

What is B20?

A Blend of 20% biodiesel and 80% diesel fuel.

B20 provides 98-99% as much power, torque, and fuel efficiency in transportation applications

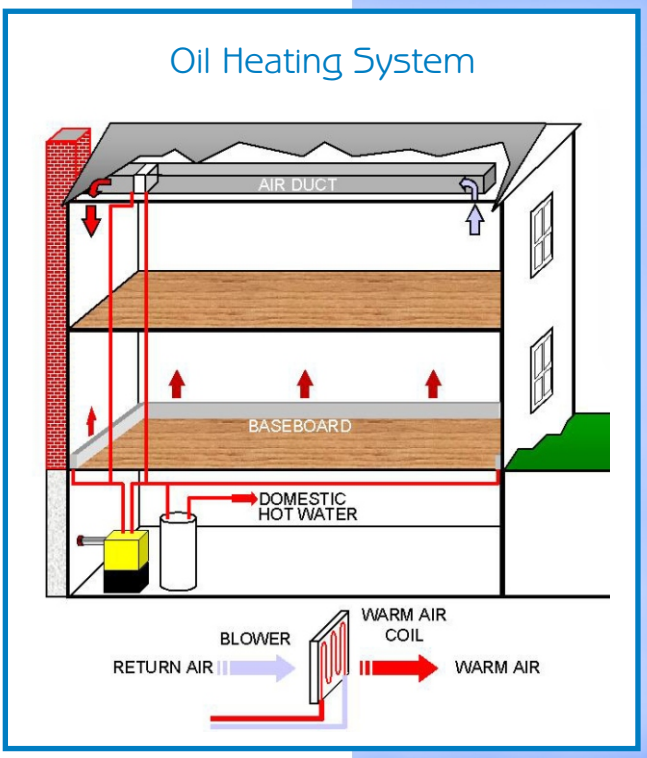
Research Applications of Biodiesel Fuel

Biodiesel is manufactured from vegetable oils, recycled cooking grease, or animal fats. It offers a renewable "green fuel" that may contain between zero and 25ppm of sulfur. Biodiesel mixed with heating oil in residential and commercial boilers may offer new market opportunities for the heating oil industry. Sulfur reductions will result in lower maintenance costs through less corrosion and fouling of heat exchangers. Additionally, biodiesel may be produced domestically, separating supply and pricing from the petroleum industry. However, B20 and B100 **biodiesel performance and applications need further research** for their use in building environments. Topics of investigation include cold storage, biodiesel and oilheat blends for maximum fuel efficiency, and identification of equipment problems related to biodiesel use. Research results should be demonstrated in written publications, at conferences and trade shows.

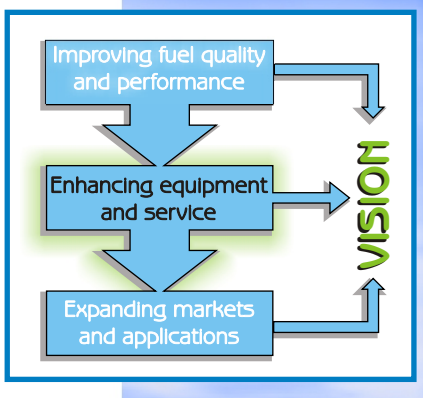
Enhancing Equipment & Service

Enhancing Equipment and Service

Oil-fired heating systems consist of several subsystems. The oil burner pump draws fuel from the tank, which is atomized and mixed with just the right amount of air for efficient combustion. An electric spark provides the ignition for the fuel/air mixture; and the flame produces heat in a combustion chamber, which is released to the heat exchanger. Air is thus heated in the furnace or water in the boiler. The heated air or hot water is routed through ducts or pipes to radiators or hot water baseboard units located throughout the building. By-products of this combustion process, which primarily include water vapor, carbon dioxide and minor amounts of sulfur dioxide, nitrogen oxides, and particulate matter, are exhausted to the outside ambient environment through a flue pipe connected from the heat exchanger to a chimney or a direct ventilation system.



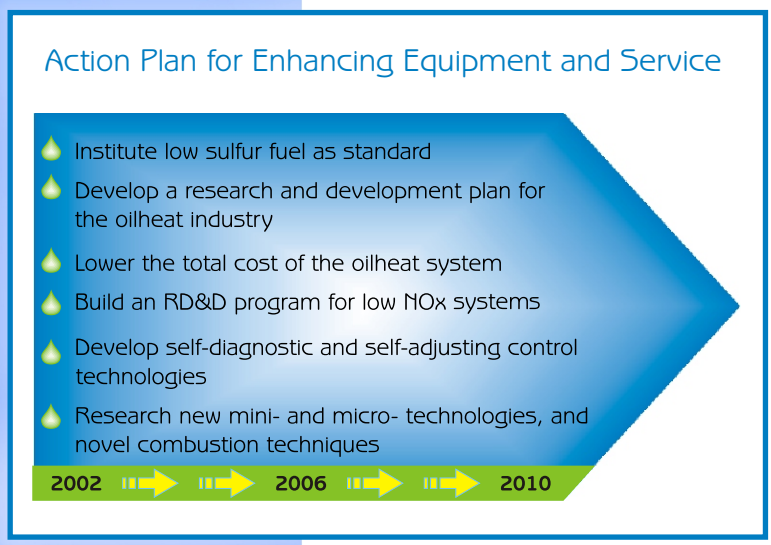
These oilheat subsystems consist of many parts, which work in a harmonious fashion to produce heat efficiently. When there is a malfunction in the oilheat system, a highly trained technician has to be able to diagnose and fix the problem in a timely manner. Enhancements in oilheat equipment and service will reduce malfunctions, lower total installed system costs, maintain high efficiencies, and lower environmental emissions, ultimately leading to an expansion of markets and applications for oilheat.



Barriers

Listed below are the most critical barriers facing oilheat equipment and service:

- **High equipment costs—**The installed cost of oilheat systems is generally higher than competitive but less efficient heating systems. This higher cost discourages homebuilders from initially installing an oilheat system and homeowners from retrofitting their existing heating systems.
- **Poor acceptance of new technology—**Industry and government attitudes fail to recognize that new technologies will improve system performance.
- **Lack of ultra-low NOx techniques—** Lowering NOx emissions will reduce overall emissions from oilheat systems and further enhance the fuel's environmental friendliness.



Actions

The oilheat industry has identified six key actions to enhance equipment and service and help achieve the vision for the oilheat industry.

Institute Low-Sulfur Fuel as Standard

Many equipment and service problems are related to fouling of heat exchangers. The cause of the fouling is from build-up on the heat exchanger surface, mostly iron sulfate scale deposits. Iron sulfate scale is caused when sulfuric acid condenses on heat exchanger surfaces below the dew point temperature of the system. Sulfuric acid results from reactions caused by heating oil combustion. The average sulfur content of residential heating oil is 0.25% by weight, while low-sulfur fuel (.05%) is mandated for highway diesel. Lowering the sulfur levels of residential heating oil could eliminate 80% of SO_2 emissions from oilheat systems (BNL). **Instituting a low-sulfur fuel standard** will not only improve environmental performance, but also increase equipment reliability and maintain system efficiency.

Lowering the sulfur levels of residential heating oil could eliminate 80% of SO_2 emissions from oilheat systems

Education materials, including brochures, white papers, and presentations, should be appropriately provided to federal agencies concerned with high sulfur levels, such as the U.S. Department of Energy (DOE) and the Environmental Protection Agency (EPA).

Develop a Research and Development Plan for the Oilheat Industry

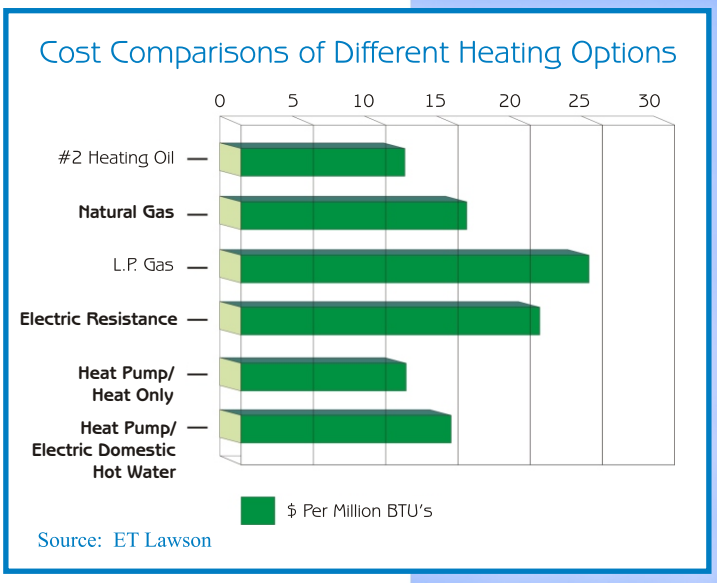
This activity focuses on development of both a **basic and applied research and development plan** for the industry. Such a plan would include R&D on burners, fuel quality, water heating, integrated appliances, hydronic heating, air conditioning, heating, cooling, indoor air conditioning, and building energy systems (BCHP), among other products, technologies, and systems.

This research and development plan will build upon the following actions:

- Lower the total installed cost of the oilheat system
- Build a Research Development and Demonstration (RD&D) Program for low NOx systems
- Develop self-diagnostic and self-adjusting control technologies
- Research novel combustion techniques

Lower Total Installed Cost of the Oilheat System

BTU for BTU, heating oil is cheaper than natural gas or propane; but the high installation cost of oilheat equipment deters many builders and homeowners from using this fuel. **Lowering the total cost of highly efficient systems** is critical for oilheat to penetrate more of the heating market. The first step is to establish a target for a competitive, installed system cost by comparing installation costs of other heating options. By determining system cost— broken down by its individual components—areas that need the most improvement will be obvious. These low cost performance numbers and individual component costs will give researchers and manufacturers direction on lowering total installation cost.



Additional analysis is needed on existing data and field studies that will result in development of algorithms for firing rates, oversized equipment, etc. that the oilheat industry can use as a "best practices" guide. Alternatives such as instantaneous systems also need to be addressed. These no-storage systems would eliminate the high capital costs required by on-site installation.

Build an RD&D Program for Low-NOx Systems

Environmental policy greatly influences energy policy. Pollutants such as sulfur dioxide and nitrogen oxides continue to cause acid rain and smog across the United States. The primary generator of these pollutants is the electric power industry. Centrally located power plants generate electricity for millions of households, many of which have electric space conditioning systems. These systems demand a substantial amount of electricity, which directly contributes to emission of harmful pollutants. Fossil-fuel fired heating systems emit tiny amounts of SO_2 and NOx. **Building an RD&D program for low and ultra low-NOx equipment** will lower emissions from oilheat and showcase its environmental performance. A low-NOx program would establish an emissions target of 65 ppm, which would bridge the gap to an ultra-low-NOx target of 20 ppm.

Once low-NOx equipment is widely available, an educational program needs to be developed for the industry on the benefits of low-NOx equipment and proper deployment

Novel burning techniques could revolutionize the industry, making oilheat a near zero-emission, highly efficient, low cost fuel.

Develop Self-Diagnostic and Self-Adjusting Control Technologies

Oilheat equipment requires more service than less efficient competitive heating systems and does not take advantage of state-of-the-art technologies, such as sensors and controls, to effectively manage it. Technologies, such as flame quality indicators (FQI), monitor performance of oil burners over time. These monitors give warnings to the dealer and homeowner when the burner needs to be serviced, before heat exchanger fouling occurs. By incorporating **advanced diagnostic technologies**, such as the Advanced Flame Quality Indicator, the oilheat system can self-diagnose problems and save technicians from taking time to fix them. By 2004, the goal is to develop field-level diagnostic methods for maintaining flame quality. **Self-adjusting technologies** will thus compensate and correct problems, limiting unplanned service calls to once every two to three years.

Research Novel Combustion Techniques

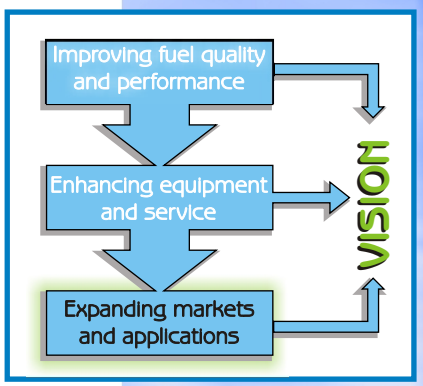
Since, oil in its liquid form will not ignite, it presents a barrier because it requires extra energy to burn. The oil is first atomized into drops, evaporated, and then burned. Because of technology used to achieve atomization, oilheat systems are often oversized and thus inefficient. **Novel combustion techniques**, such as modulating burners and low-fire concepts, will improve system efficiency. These techniques could revolutionize the industry, making oilheat a near zero-emission, highly efficient, low cost fuel. The industry's goal is to develop and produce modulating burners with an integrated design for better sizing by 2008. Research laboratories have the capability today to conduct research on new methods of burning oil; continuing this research is an important ingredient of increasing the market for oilheat in the future.

Expanding Markets & Applications

The oilheat market has remained flat, or has declined, during the last twenty-five years. As a result, the industry is developing new strategies to maintain and grow its market share while utilizing oil in innovative, potentially revolutionary ways. Market share improvements -- retaining existing customers and reaching out to new ones, enhancing marketing and advertising, and changing the public's perception of oilheat - must be on the industry's agenda if its future is to grow brighter. New and expanded applications for oil are being investigated as well, including use of oil-fired energy systems for integrated buildings, cooling, heating, and power; on-site electric generation; domestic hot water and air conditioning; desiccant cooling systems; photovoltaic systems; and fuel cells.

Among the industry's goals for the long term future are:

- Changing the public's perception to one of oilheat as a clean, cost-effective, and versatile fuel
- Accelerating electric-to-oil conversions in existing buildings, and improving the market share for oilheat systems in new construction by 5-10% by 2020
- Expanding energy efficiency and distributed energy services to oilheat customers, including on-site electric generation, oil-fired, energy efficient space and water heating and cooling, and oil-fired integrated buildings, cooling, heating, and power (BCHP) systems



Barriers

A significant **barrier** standing in the way of new and expanded markets and applications for oil is the lack of utilization of high-tech equipment, including oil burners, advanced diagnostics, and compact equipment that can be installed more successfully into new and remodeled buildings. Ancillary to this barrier is the lack of high quality monitoring equipment and systems to measure flame quality and tank construction, and the lack of diagnostic tools for on-site analysis.

The most critical **market barrier** to improving the market penetration for oilheat is the challenge of articulating the message to consumers that the product is clean, low cost, and safe. Consumers believe that oil is not secure, that supply interruptions are common. This is untrue. Eighty-five percent of heating oil is refined in the United States;

90% of crude oil is derived from sources friendly to North American interest. As a result of misconceptions, builders, contractors, and designers rarely specify oilheat, and do not utilize it even when available.

If oil is to be a competitive product, the marketplace needs to grow. Not only should it be considered for residential and commercial heating needs, but it needs to be utilized in institutional environments. Space heating has been oilheat's "bread and butter" market, but its use for space cooling, integrated energy systems, and distributed power generation must increase for the total market to improve. Oil dealers, themselves, believe that their industry is in a "no-growth" mode; they need to market themselves, and their product, for oil to compete in the 21st century.

Actions

The oilheat industry has identified six priority actions to address the barriers listed above and to achieve the vision that all industry stakeholders support for the future:

- Change consumer perceptions about oilheat
- Improve builder education and incentive programs
- Grow an educated oilheat workforce
- Research potential growth markets
- Increase electric to oil conversions
- Integrate oilheat with new, advanced building technologies, equipment, and systems

Change Consumer Perceptions About Oilheat

This action, designed to **change consumer perceptions about oilheat**, is an extremely high priority for the industry. If consumers become convinced that oilheat is clean, energy efficient, and cost effective, the market for the fuel will improve over time. The primary action item for this activity is to advertise the benefits of oilheat to consumers through television, radio, and newspaper advertising; direct mail; internet advertising and information; and brochures and bill stuffers. A public relations (PR) campaign is also envisioned, including design and placement of effective informational pieces in trade journals and newspapers; targeted presentations for industry leaders at conferences and meetings in selected markets; and utilization of public service announcements and incentive programs.

Improve Builder Education and Incentive Programs

The focus of this action is new home construction, both tract and luxury models. There is a need to develop builder-grade products and programs that are attractive, both in terms of design and cost, to builders on a mass-market scale. Similar to marketing methods that have been used by both the gas and electric industry, the oilheat industry needs to work cooperatively with builders to create **opportunities and incentives for them to build with oil.** Builders and contractors will respond to financial incentives, such as reduced equipment installation fees, or free tanks, and creative marketing opportunities, such as "piggy-back" advertising in newspapers and local public relations materials.

Other elements of this action item include design of cost-competitive and efficient tanks and oilheat systems; development of a marketing program to improve subsidies for oilheat products; and development of marketing and outreach tools for builders. In addition, sales training for oil marketers will help the industry better communicate and coordinate their efforts with the building industry.

Grow an Educated Oilheat Workforce

It is critical for the future health of the oilheat industry that **new employees are attracted into the field** and that existing staff be better trained and educated, so as to utilize new energy technologies, products, and systems. Existing education programs need to be upgraded and targeted recruitment programs need to be designed and implemented. Creation of an "Oilheat Institute" or training center, with technical classes, student counseling, certification classes, and scholarships, among other activities, is a key part of this activity. NORA would be the lead organization for this Institute, with support from other national organizations such as the National Association of Oilheat Service Managers (NAOHSM), state and regional organizations, individual oilheat combustion companies, and other technical schools with specialties in integrated buildings, CHP, distributed energy technologies, etc. NORA currently is developing educational and training strategies; this effort will continue indefinitely. The current annual education and training budget is $3 million; this is expected to grow.

Research Potential Growth Markets

Researching potential growth markets will allow the oilheat industry to focus on specific areas and applications to expand their service. Potential short-term growth markets include: new residential construction, domestic hot water, and retrofits of electric resistance and furnace systems. Mid- to long-term market growth includes cooling and retrofits from propane to oil. A market research study should be initiated, with support from energy laboratories and the industry itself, to identify and measure potential growth opportunities, within ten to twenty years.

Increase Electric to Oil Conversions

Over the last twenty years, conversions from oil to gas or electricity have substantially increased throughout the country. Because electric resistance heating is only 33% efficient as compared to oilheat, the industry is anxious to **increase electric to oil conversions**. Specific action items to accomplish this include market research on conversion opportunities (e.g., cost-benefit analyses, installation of sample units, etc.); technology research, development, and demonstration; and a builder retrofit market study. A "concept study" that analyzes quick installation of a packaged conversion system integrated with energy storage, would be an important first step. A concept for a packaged system, which can be easily installed in a conversion, should be available by 2005, with analysis and evaluation conducted by 2008.

Diesel Micro Turbine Electric Power Generator

Integrate Oilheat with New, Advanced Building Technologies, Equipment, and Systems

In order for oilheat to compete in today's marketplace, it must become better **integrated with new, more advanced heating, ventilation, air conditioning, and power supply technologies, equipment, and systems**. Among others, these include packaged buildings cooling, heating, and power systems and renewable energy systems, such as fuel cells and solar heating and cooling. Research, development, and demonstration projects on new, advanced technologies, equipment, and systems will lead to commercial-ready products and systems. Cost-shared RD&D will garner support among industry, laboratories, and trade associations.

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